Notes: Ch 10 Fill-in-Blank (pg 12-15)

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Chapter 10 Earthquakes

Earthquake - when the strength of the lithosphere fails and it snaps or shifts suddenly in response to built-up stress
- occur along faults or plate boundaries.

stress - force applied to an object
- compressive stress - squeezing the object
- tensile stress - pulling object apart
- shearing stress - cause diff parts of object to move in different directions, slide past other part.

strain - deformation, a change in shape and/or volume due to stress, temporary or permanent
- elastic deformation - returns to original size, etc when stress removed, shape changes temporary
- plastic deformation - when elastic limit of a material is reached, shape changes permanent add small extra stress = large change in shape
- rupture - material breaks if stress increased, brittle materials will rupture earlier, colder = more brittle

rocks usually stronger under compression than tensile stress

fault
creep - movement along existing faults that occurs gradually and smoothly (broken curbs)

when there is no creep (friction or no fault prevents) stress accumulates energy until rupture = earthquake, then stressed rocks, released, snap back to original dimension, called elastic rebound.

Parts of an Earthquake

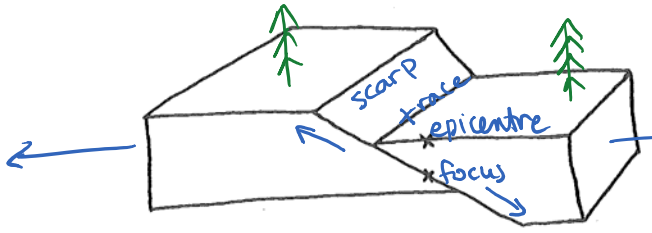
focus - ~~(or hypocenter)~~ the point on a fault at which the first movement or break occurs during an earthquake

epicenter - the point on the earth's surface directly above the focus

fault-trace - the line along which the fault plane intersects the earth's surface

fault-scarp - the cliff formed if there is vertical movement along the fault

Label the diagram



Tensile stress

Normal Fault
Diverging plates

most earthquakes occur at plate boundaries

deep-focus earthquakes (>100km deep)
- only occur in subduction zones where brittle, cold, lithosphere is pushed into mantle (other plate boundaries would only have shallow focus since brittle lithosphere isn't pushed down)

Seismic Waves - stored up energy released in earthquake, travel away from the focus

body waves (P and S) - travel through interior of earth

surface waves (L) - travel along surface

Primary P waves - compressional waves (like sound in air), travel faster (on average 2x as fast as S waves)

secondary S waves - shear waves (side-to-side sliding motion of material), travel slower, go through solids only

used to determine epicenter - P waves arrive first to seismograph

Seismograph - instrument used to detect ground motion caused by P and S waves

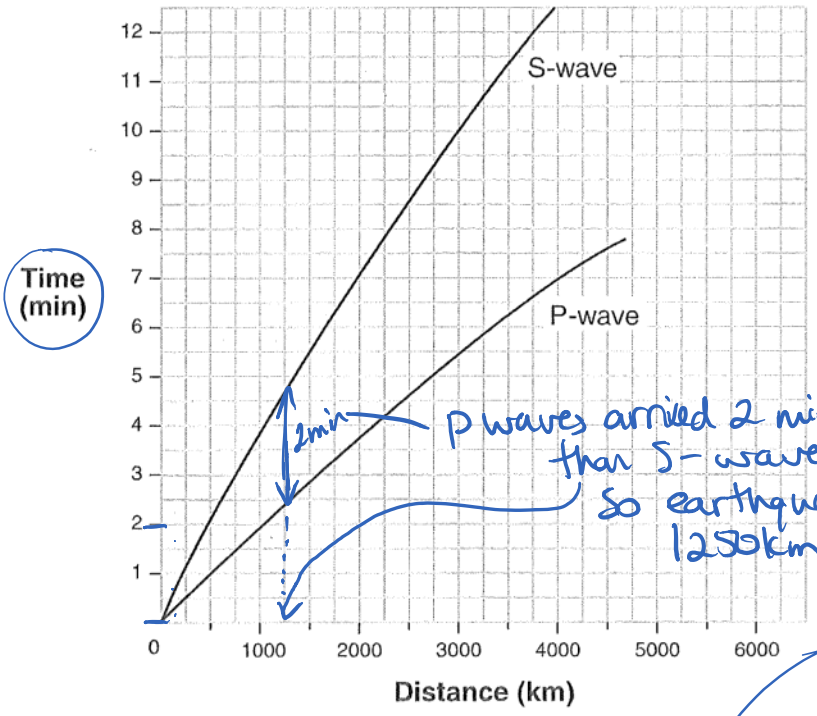
the difference in arrival time between P and S waves is a function of the distance travelled (see graph in Fig 10.8)
the further they travel, the further ahead the P-waves get
Need 3 seismograph stations at different places to pinpoint an earthquake exactly (actually need more)

Surface waves - cause ground surface "ripples" like in water, cause most earthquake damage
Rayleigh waves - cause vertical ground motions
Love waves - cause horizontal shear motion

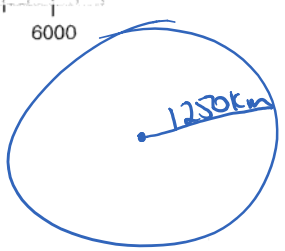
Magnitude - amount of ground shaking or vertical motion, usually reported by Richter Magnitude scale, ~~adjusted for from epicenter~~ or amount of energy released

Richter Scale - logarithmic measure of magnitude
i.e. magnitude 5 is 10X ground movement as magnitude 4
magnitude 5 is 100X ground movement as magnitude 3
etc
- for every increase in magnitude, energy released goes up by 30 times.
- No upper limit, max recorded was ~~8.9 in Japan and Ecuador~~ 9.5 Chile in 1960

P and S Seismic Wave Travel Time Graph



P waves arrived 2 min earlier than S-waves so earthquake happened 1250km away



P

S

Modified Mercalli Scale

Rating	Description
I	Barely felt.
II	Felt by a few sensitive people, some suspended objects may swing.
III	Slightly felt indoors as though a large truck were passing.
IV	Felt indoors by many people, most suspended objects swing, windows and dishes rattle, standing autos rock.
V	Felt by almost everyone, sleeping people are awakened, dishes and windows break.
VI	Felt by everyone, some are frightened and run outside, some have trouble walking, some chimneys break, some furniture moves, slight damage.
VII	Considerable damage in poorly-built structures, felt by people driving, most are frightened and run outside.
VIII	Slight damage to well-built structures, poorly-built structures are heavily damaged, walls, chimneys, monuments fall.
IX	Underground pipes break, foundations of buildings are damaged and buildings shift off foundations, considerable damage to well-built structures.
X	Few structures survive, most foundations destroyed, water moved out of banks of rivers and lakes, avalanches and rockslides, railroads are bent.
XI	Few structures remain standing, total panic, large cracks in the ground.
XII	Total destruction, objects thrown into the air, the land appears to be liquid and is visibly rolling like waves.

Intensity - a measure of the earthquake's effects on humans and surface features
- same magnitude earthquake can give varied intensity depending on local geologic conditions, quality of structures, distance from epicenter, the observer's description

Modified Mercalli Scale - most widely applied intensity scale

Hazards
1) Ground shaking and displacement along the fault
Solutions
- build city elsewhere
- put slack in pipelines crossing faults
- design earthquake resistant buildings
(difficult - no data of waves in major quake
- can't reproduce in lab)
- built on solid bedrock rather than deep soil
- consider characteristics of quakes in region
- aftershocks - weaker than principal tremor, many of these follow original quake
- duration - if building can only last 25 sec of quake and it lasts 250 sec . . .
(can't tear down all the old buildings though!!)

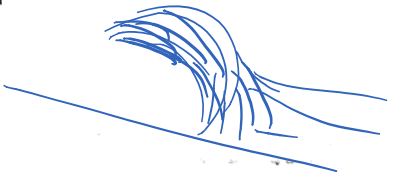
adobe - mixed earth and sand

2) Secondary hazard - fire
- fuel lines and power lines, spark = fire
- water mains break, can't douse flames
Solution
- put many valves so can shut off affected area

3) Landslides - hilly areas
- quakes may trigger unstable slope to slide
Solution
- don't build there

4) Liquifaction
- wet soil shaken by quake, soil particles jarred apart, water seeps between, looses strength, becomes like quicksand, buildings topple or sink
Solution
- keep soil dry (drainage)
- avoid the area (Richmond)

5) Tsunamis - seismic sea waves
- sudden movement of sea floor may set up waves
- in mid-ocean is just broad swell
- breakers when reach shore >15m easy and up to 65m
- travel up to 1000km/hr
- can warn people far enough away



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Earthquake Control?

Seismic gaps - spots on active fault zones that are quiet (locked?)
- need way to release fault gently and controlled
- fluids in fault zones may help movement
- fluid injection? don't know enough yet, too dangerous

Earthquake Prediction

- save lives, not property
- based on precurser phenomena - things that happen or rock properties that change prior to an earthquake
  - i.e. ground surface uplifted or tilted
    P wave velocities drop then rise
    electrical resistivity increase then decrease
    increase in radon concentration in wells
    changes in water levels in wells
    anomalous animal behaviour
- in general, length of time over which precursor phenomenon occurs is related to quake size: longer = larger
- not all quakes show same pattern of precursor
- some great successes, some failures in prediction
- quake forecast - less precise prediction
- would people listen anyway?!

pg 214 - 219 -- good examples of earthquakes -- READ!

Important Facts about our Planet Earth and the Universe

PLANET Earth is 4,600,000,000 years old, has all 94 natural chemical elements, and supported life for about 3 to 4 billion years. Modern Man is only 10,000 years old. Today the estimated world population is 5.5 billion and growning at a rate of 84 million people per year. In addition, there are billions of plant and animal life forms inhabiting our planet. Physically, Planet Earth is an oblate spheroid. Polar diameter is 7,900 miles, equatorial diameter 7,926 miles, circumference at the equator is 24,901 miles, 24,860 at the meridian. The surface area is approximately 196,937,400 square miles. The period of a rotation sidereal day is 23 hours 56 minutes 4.0996 seconds. The mass of the Earth is 658,560 trillion tons and volume is approximately 259,875,300,000 cubic miles. Area covered by water is 139,670,000 sq. miles or 71% of the surface. Fresh water is only 3% of the total water on the planet, with 81,200,000 sq. miles or 29% of land above water. Forests and rangelands cover 84% of the planet's surface.

Earth, the 3rd planet of nine from our Sun, has one moon whose mean distance from Earth is 238,855 miles center to center. The Earth and the moon travel an average 66,620 MPH (miles per hour) on an elliptical orbit of 584,017,800 miles around the Sun. Distance from Sun at perihelion 91,402,00 miles and aphelion of 94,510,000. Our solar system travels around the center of the Milky Way galaxy once every 225,000,000 years at a speed of 481,000 MPH. The Milky Way Galaxy 10,000 light years* thick (1 light year is 5,878,499,814,000 miles long) and 100,000 light years wide travelling anywhere from 500,000 MPH to 1.1 million MPH in the direction of the constellation Virgo.

There exists 10,000 million other galaxies in the universe. The age of the universe is now estimated at 8 to 18 billion years. So far life and intelligent life is unique to our planet Earth, but the search continues to seek life on other Worlds.

*Light years equal distance light travels in 1 Earth year (365 days) at 186,000 miles per second.

Our planet Earth being part of our larger solar system originated from a turbulent cloud of dust, gas and asteroids surrounding our sun. The cloud settled over a period of 700 million years placing the planets into the calm orbits they now occupy. Our planet then began to harden. This is believed to have occurred approximately 4.5 billion years ago. Planet Earth is considered to be in its mid-life. The natural destruction of the Earth will occur in 4 to 5 billion years when the sun will have burned all its own hydrogen fuel causing it to expand and incinerate all the surrounding planets.

The Earth's atmosphere is approximately 18,000 miles wide. Our weather is restricted to the first 5-10 miles. Most or 99% of the atmosphere is condensed into the first 50 miles.

There are approximately 2,200 thunderstorms at any given moment on the Earth, and lightning is over 5 times the temperature of the surface of the sun, or 30,000 degrees Centigrade.

There are 1.7 million plant and animal species on the Earth that are catalogued and known to exist. On the other side, there are believed to be 5 to 35 million the we do not even know about. The land surface on Earth is only 29.2% of the total surface of the Earth or 57,514,000 square miles.
The Earth's History is subdivided as follows: Precambrian - began 4-5 billion to 600 million years ago. Paleozoic -600 million to 200 million years ago. Mesozoic - 200 to 60 million years ago. Cenozoic - 60 million years to the present, (last ice age, 10 million years ago).

A few ways to protect our fragile planet for the future:
Plant trees! A fast growing tree can recycle 48 pounds of carbon dioxide each year. Buy energy efficient appliances. Recycle as much as possible, including newspapers, aluminum, glass, and other materials. Make sure your house is well insulated, this saves energy. Educate your family and friends. Support environmental conservation organizations that are fighting to save our planet. Write to your government explaining your support of environmental legislation and action.

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Dilatancy model - when pressure is building cracks and pores open up in rocks

allowing water to enter. This lubricates and allows the rocks to slip and release the built up stress = equake.

Best place / type of house to build:

- on bedrock (glacial till is pretty good)
- away from fault
- not at bottom of hill
- wooden frame bolted to foundation.